

Site Characterization Needs from a Risk Assessment Perspective

Mike Stenhouse, Wei Zhou, Randy Arthur,
Monitor Scientific, LLC

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Outline of Presentation

5 Questions?

4 Conclusions



1 Role of risk assessment

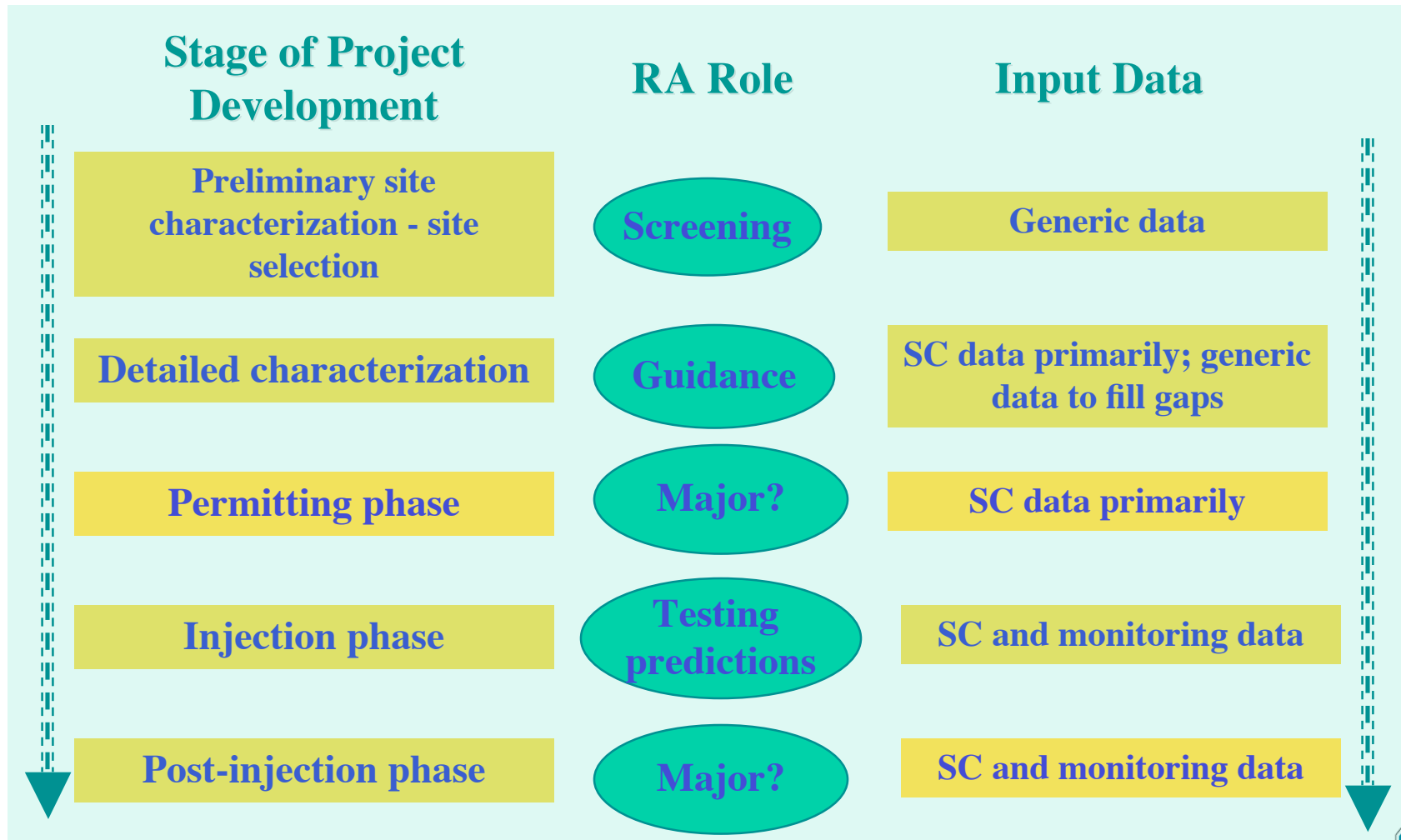
2 Risk assessment process - basics

3 Risk assessment needs from site characterization

Risk Assessment: General

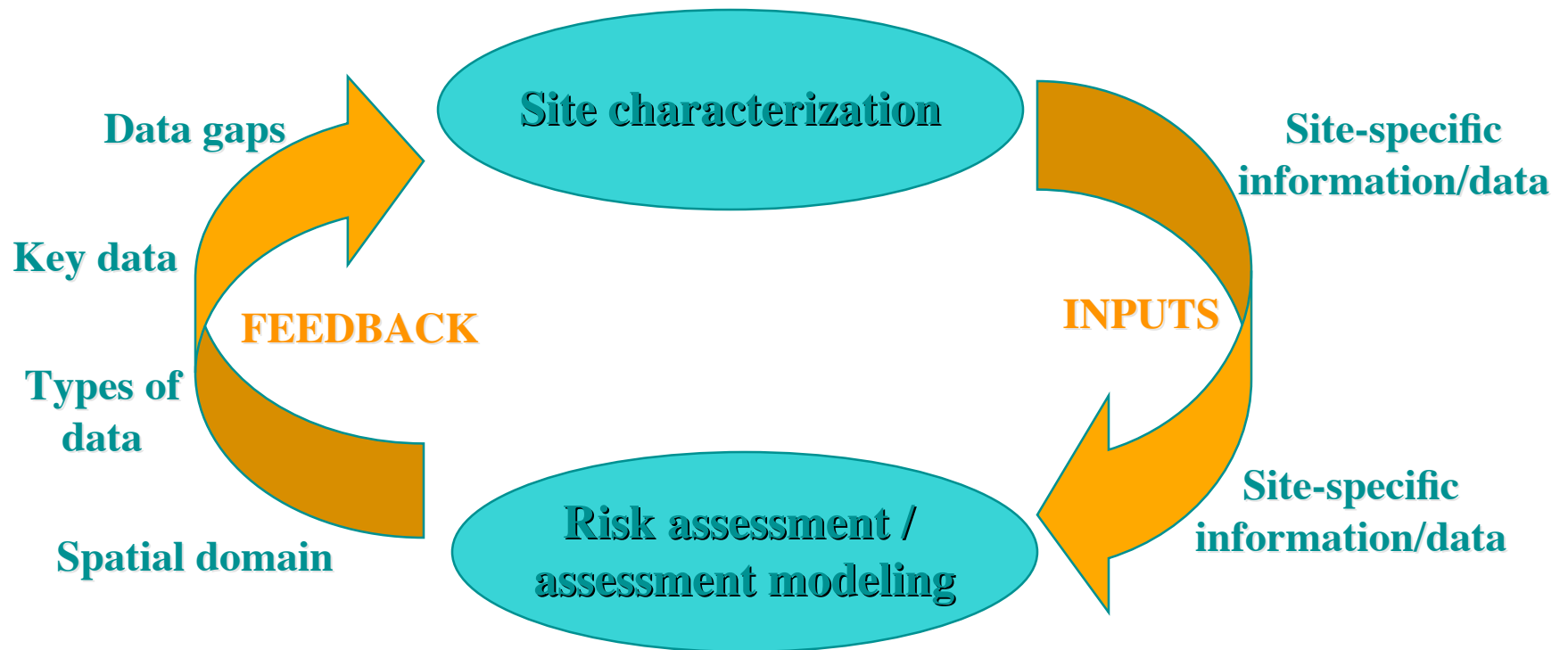
- Risk is the likelihood of suffering harm from some activity
 - Post-injection phase of CO₂ storage
- Risk assessment (RA) is the process of:
 - identifying potential hazards
 - assessing the magnitude of the consequences from each particular hazard (H)
 - assessing the likelihood of its occurrence (probability)
- Formally may be expressed as:
$$Risk_H = Consequences_H \times Probability_H$$

Perceived Role of Risk Assessment



RA = risk assessment; SC = site characterization

RA - Iterative Process



Risk Assessment Process

- Framework of *scenario analysis*
 - Scenarios are plausible/credible ways in which the storage reservoir and its surroundings might evolve
 - Scenarios are supported by consideration of *features*, *events*, and *processes (FEPs)*
 - FEPs are those factors that need to be considered when modeling integrity of storage system
 - Generic FEP database available containing descriptions of different FEPs



Quintessa

CO₂ FEP Database

Risk Assessment

Database: Generic

178 records were found that match your criteria.

Click on the links below to view the FEP records.

0 [Assessment Basis](#)

- ☐ 0.1 [Purpose of the assessment](#)
- ☐ 0.2 [Endpoints of interest](#)
- ☐ 0.3 [Spatial domain of interest](#)
- ☐ 0.4 [Timescales of interest](#)
- ☐ 0.5 [Sequestration assumptions](#)
- ☐ 0.6 [Future human action assumptions](#)
- ☐ 0.7 [Legal and regulatory framework](#)
- ☐ 0.8 [Model and data issues](#)

1 [External Factors](#)

- ☐ 1.1 [Geological factors](#)
 - ☐ 1.1.1 [Neotectonics](#)
 - ☐ 1.1.2 [Volcanic and magmatic activity](#)
 - ☐ 1.1.3 [Seismicity](#)
 - ☐ 1.1.4 [Hydrothermal activity](#)
 - ☐ 1.1.5 [Hydrological and hydrogeological response to geological changes](#)

<http://www.quintessa-online.com/CO2>

4 [Geosphere](#)

☐ 4.1 [Geology](#)

- ☐ 4.1.1 [Geographical location](#)
- ☐ 4.1.2 [Natural resources](#)
- ☐ 4.1.3 [Reservoir type](#)
- ☐ 4.1.4 [Reservoir geometry](#)
- ☐ 4.1.5 [Reservoir exploitation](#)
- ☐ 4.1.6 [Cap rock or sealing formation](#)
- ☐ 4.1.7 [Additional seals](#)
- ☐ 4.1.8 [Lithology](#)
 - ☐ 4.1.8.1 [Lithification/diagenesis](#)
 - ☐ 4.1.8.2 [Pore architecture](#)
- ☐ 4.1.9 [Unconformities](#)
- ☐ 4.1.10 [Heterogeneities](#)
- ☐ 4.1.11 [Fractures and faults](#)
- ☐ 4.1.12 [Undetected features](#)
- ☐ 4.1.13 [Vertical geothermal gradient](#)
- ☐ 4.1.14 [Formation pressure](#)
- ☐ 4.1.15 [Stress and mechanical properties](#)
- ☐ 4.1.16 [Petrophysical properties](#)

☐ 4.2 [Fluids](#)



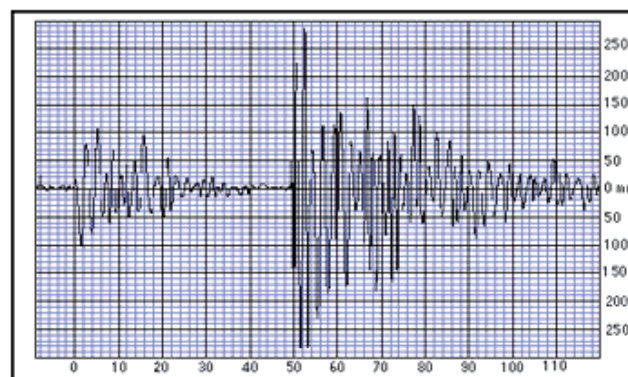
Name

1.1.3 Seismicity



Description

Events and processes related to seismic events and also the potential for seismic events. A seismic event is caused by rapid relative movements within the Earth's crust usually along existing faults. The accompanying release of energy may result in rock movement and/or rupture, e.g. earthquakes.



From USGS website

<http://www.quintessa-online.com/CO2>

Relevance to performance and safety

Seismic events may result in changes in the physical properties of rocks due to stress changes and induced hydrogeological changes. Seismic events are most common in tectonically active or volcanically active regions at crustal plate margins.

References

1. [Li X, Koide H, Ohsumi T, Li Q and Wu Z. \(2003\). Mechanical Stability of the Potential CO₂ Sequestration Sites in Japan. Pergamon, Oxford, UK](#)
2. [Holloway et al. \(1996\). The Underground Disposal of Carbon Dioxide. British Geological Survey](#)

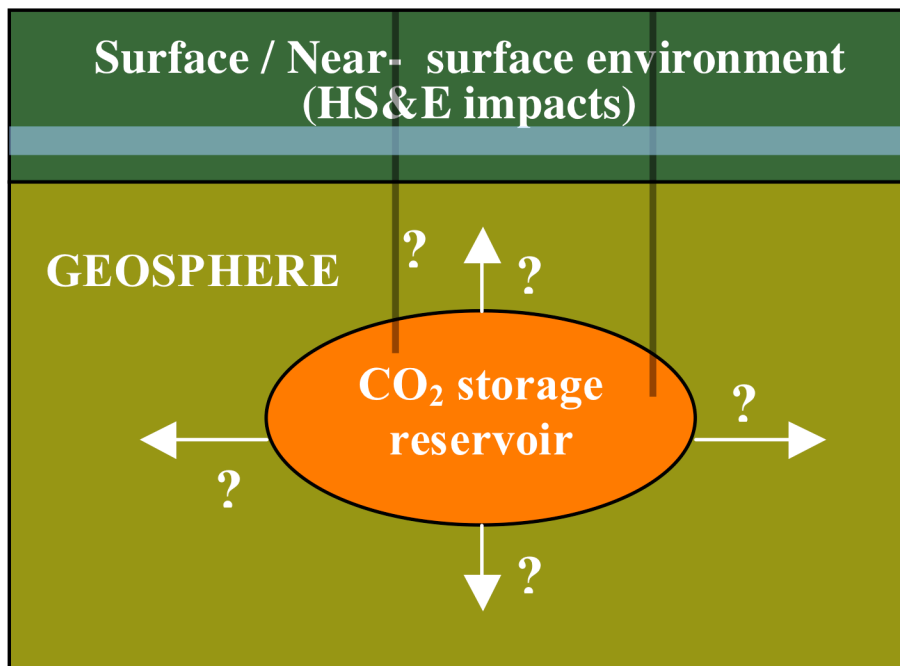
Links

1. [USGS Earthquakes](#)

Specific RA Needs From Site Characterization

- Conceptual model - physical representation of system
- Sealing system
- Preferential pathways
 - Natural (faults)
 - Man-made (wellbores)
- Wellbore characteristics
- Hydrochemical / geochemical inputs

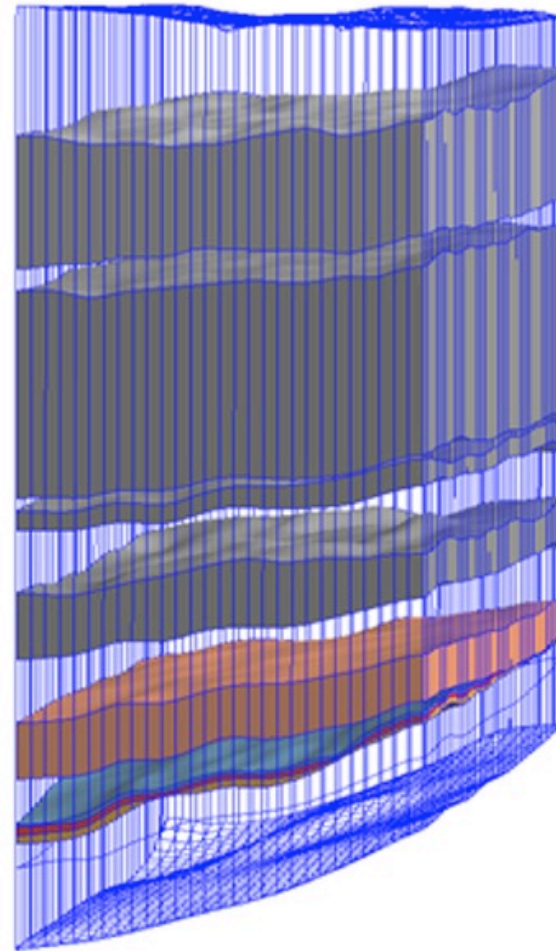
Physical Representation of CO₂ Storage System



- **Start with general conceptual treatment**
 - identify unknowns
- **Utilize geological information/data to build picture, e.g.**
 - stratigraphy, reservoir geometry, preferential pathways, hydraulic units, hydrogeology,
- **develops into.....**

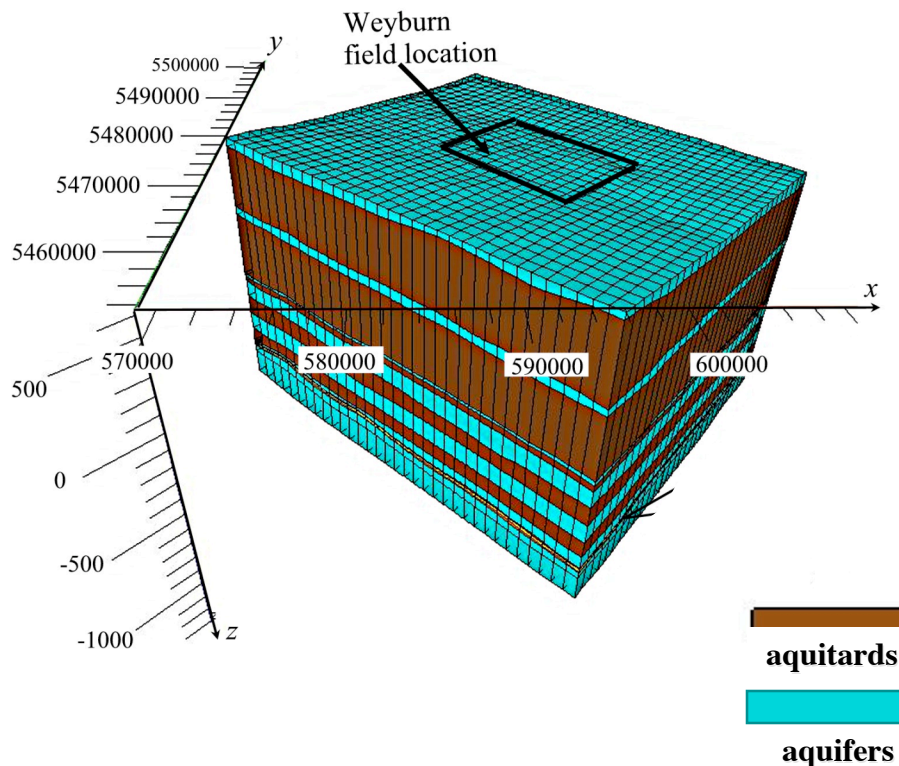
The Weyburn Geological Model

- Detailed physical representation of storage reservoir and its surroundings (natural system only shown)
- Hydrogeological characterization likely on a regional scale
- Represented in assessment modeling as.....



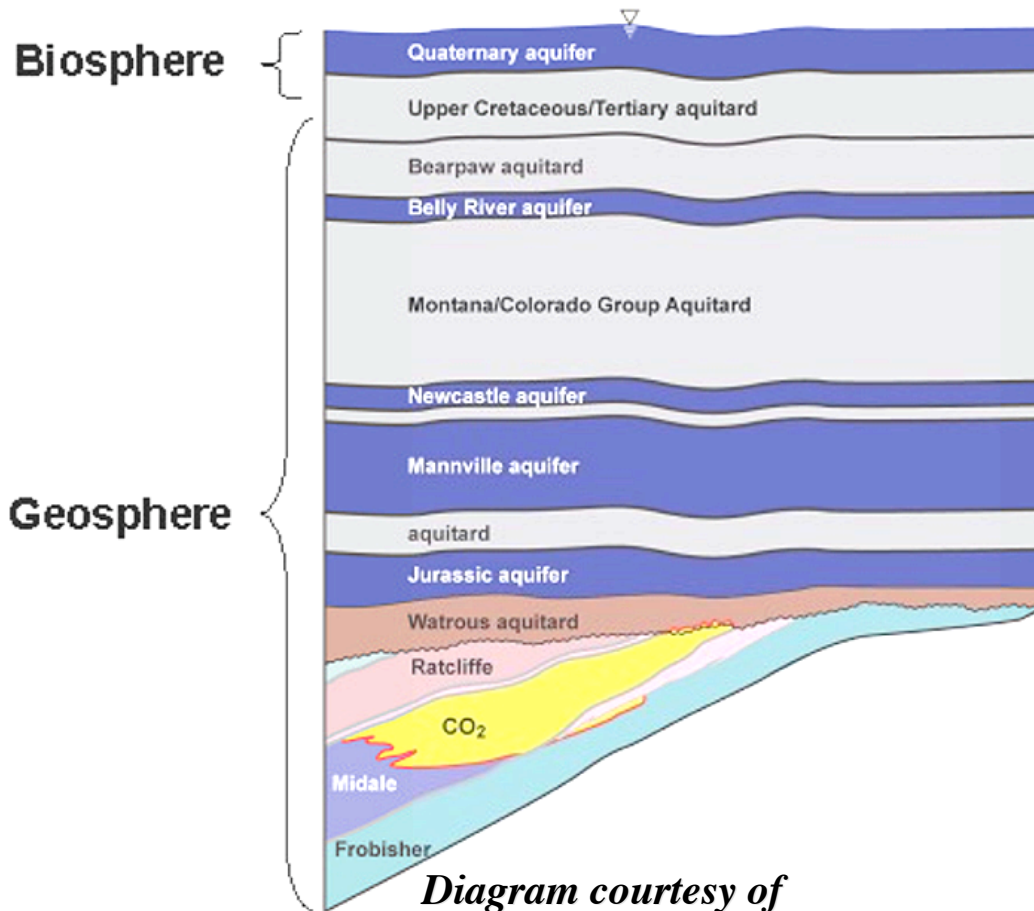
*Diagram
courtesy of Steve
Whittaker,
SIR, Regina*

Weyburn Assessment Model



- Hydraulic units represented by series of aquifers and aquitards
- CO₂ migration can occur laterally as well as vertically upwards and downwards
- Biosphere starts with deepest potable aquifer

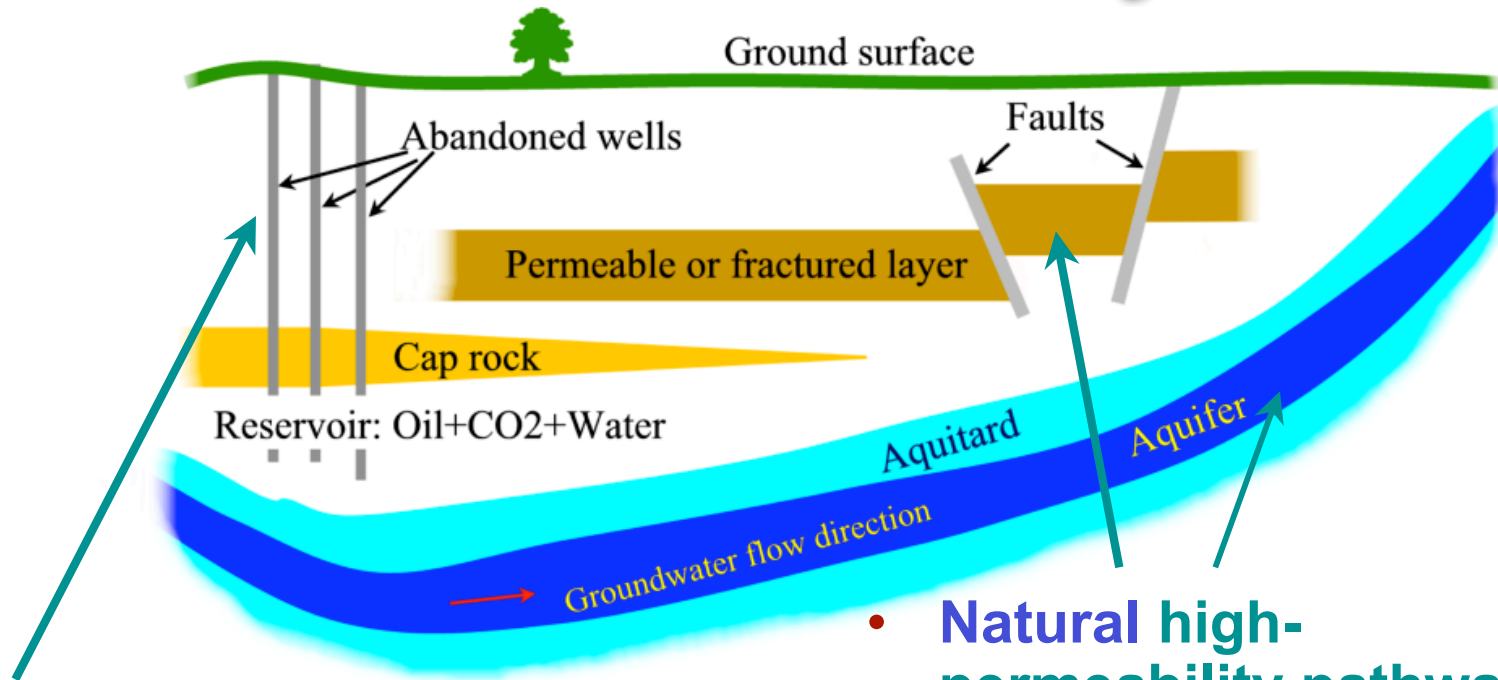
Sealing System Characteristics



*Diagram courtesy of
Steve Whittaker,
Saskatchewan Industry
and Resources*

- **Caprock**
 - Thickness, lithology, mineralogy, petrophysical properties; assess
 - potential for chemical change
 - hydraulic integrity
 - mechanical integrity
- **Secondary seals?**
 - Similar input as caprock

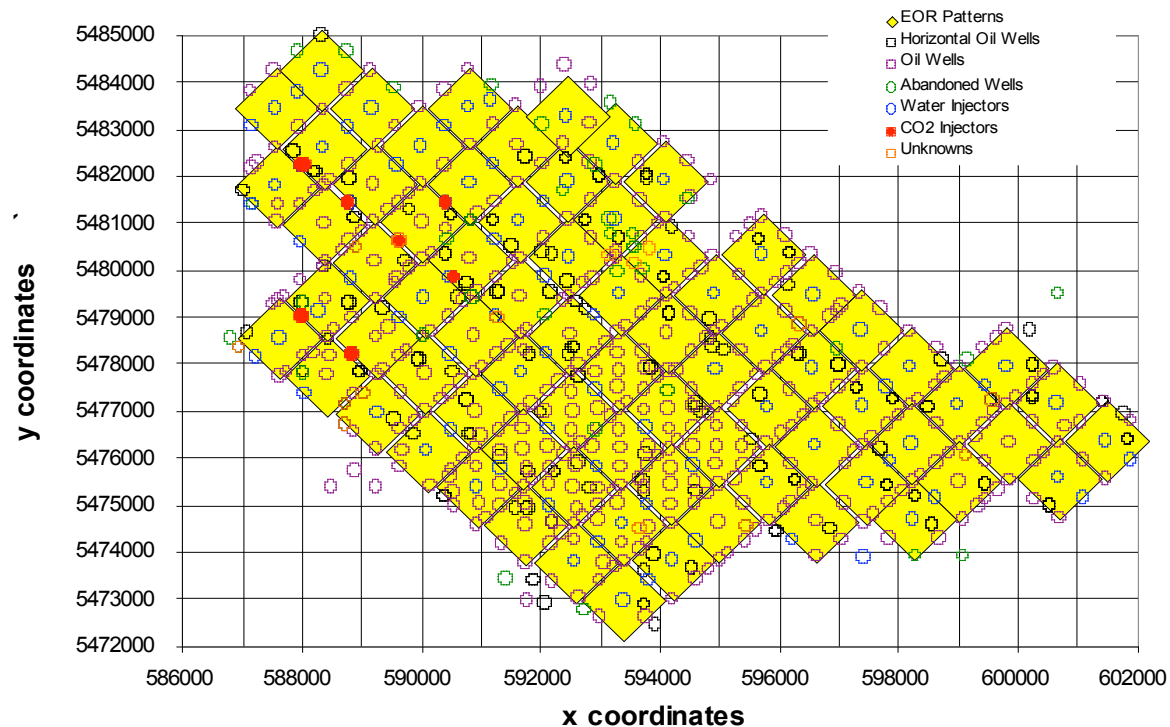
Preferential Pathways?



- **Man-made pathways**
 - Wellbore system (casing, annulus, seals)

- **Natural high-permeability pathways**
 - Faults (conductive)
 - Fracture zones
 - Fast-moving aquifer
 - => spatial domain

Wellbore Information / Data



Wells within the planned EOR area at Weyburn

- ☐ Major potential pathway for CO₂ leakage from reservoir to surface / near-surface
- ☐ Need to identify locations and wellbore status (age, abandonment procedures - closure and seals)
- ☐ Where possible, develop database of wellbore statistics

Hydrochemical / Geochemical Input

- **Mineralogy relevant to rock-water-CO₂ interactions**
 - Initial focus at, and around, reservoir
 - =>Mineral dissolution/precipitation?
 - =>Potential for mineral trapping of CO₂?
- **Near-surface aquifer hydrochemistry**
 - Ability of dissolved-CO₂ water to perturb natural system
 - Potential for trace toxic metal release?
 - Near-surface sediment sorption characteristics

Indirect Inputs

- **Heterogeneities, e.g. permeability**
 - => Directional variations in CO₂ movement
- **In support of alternative (“what-if”) types of scenario**
 - **Undetected features, e.g. fault**
 - Possibility depends on knowledge of faulting in the area combined with the resolution of characterization technique(s)
 - **Seismicity of region**
 - Provide input on possible earthquakes, their magnitude, and their associated impacts

Conclusions

- Risk Assessment provides a useful framework for guiding site characterization activities at all stages in the development of a geological CO₂ storage project.
- Besides identifying what information and data feed directly/indirectly into assessment modeling, RA can also guide decision makers on what information/data are *not* crucial to assessment predictions.

5 Questions?

